Liquids

Day:

Date: / /

→ Hydrogen Bonding

when H is directly attached with FON

HighH electro negative

FON - IMF

$H^{+\delta} \longrightarrow :\ddot{F}:^{-\delta}, :\ddot{O}:^{-\delta}, :\ddot{N}:^{-\delta}$

→ No of H-bonds

- no of H atoms (3)
- no of lone pairs (1)

e.g

$\ddot{N}H_3$ → 1 H-bond

$H\ddot{F}:$ → 1 H bond

$H_2\ddot{O}:$ → 2 H-bonds

① Structure of Ice

freezed water → irregular behaviour

In general

→ Temp ↓ Shrink

→ Temp ↑ Expand.

$0°C \xrightarrow{\text{shrink}} 4°C \xrightarrow{\text{expand}} 100°$

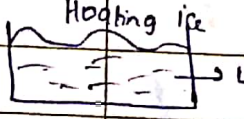
Shrink instead of expanding

$0°C \rightarrow 4°C \rightarrow 100°C$

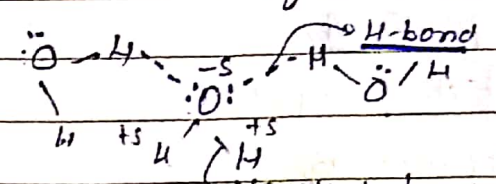
Expand Shrink

→ At 4°C density of H_2O is max

$d = \frac{m}{V}$

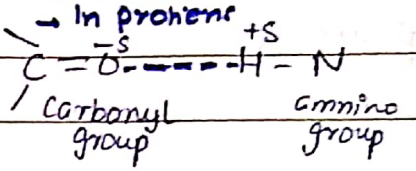


Structure of Ice



② → Biological Molecules

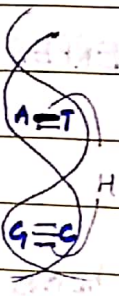
→ In proteins



→ H-bond supports the structure of protein

→ In a secondary protein (single helix) 2 7 A·A joined by H-bonding

→ DNA



18 – 20 A° (diameter)

③ Effect on thermodynamic properties of (covalent hydrides):

FON

	IV A	V A	VI A	VII A
non polar ↓	CH_4	NH_3	OH_2	HF
increases down the group	SiH_4	PH_3	SH_2	HCl
	GeH_4	AsH_3	SeH_2	HBr
	SnH_4 max B.P	SbH_3	TeH_2	HI

B.P of IV A

London dispersion forces become stronger down the group

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V A $SbH_3 > NH_3 > AsH_3 > PH_3$

Day: strong London dispersion force. Date: / /

VI A $H_2O > H_2Te > H_2Se > H_2S$

VII A $HF > HI > HBr > HCl$

high B.P due to H-bond

down the group size increase, London forces become dominant polarizability increase

→ **Solubility :-**

- Carbohydrates, carboxylic acids soluble due to H-bond in water
- Alcohols like (CH_3OH, CH_3CH_2OH)
- Cleansing Action

(carboxylic end) H_2O ← [P' soap N.P] → attaches to dirt (Hydrocarbon chain)

- Adhesive actions

Paints (attach to surfaces due to strong H-bonding)

MCQs

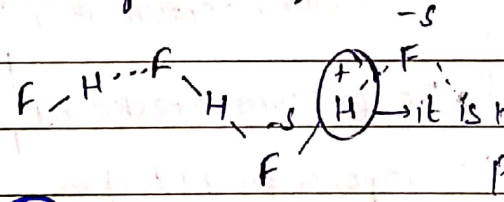
- Hydrogen bond is strongest among the molecules → H-F (ΔE.N → max)

Hydrogen bonding " → H_2O (2-Bonds)

(overall strength of molecule)

- Weakest acid →

HF



it is trapped and cannot proper function

- Strongest acid → HI → bcz it can easily lose electron
- Volatile acid → HCl

HF > HI > HBr > HCl → dipole-dipole forces (weak)

- If H_2O max → 4°C bcz water molecules fill in the spaces b/w hexagonal structure of ice
- Density of water is minimum at → 100°C (bcz it will boil, convert to gas the distance b/w molecules increase)

$d = m/v$

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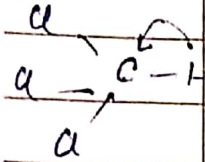
•) Two diff temperatures at which density of water is equal
← 0° and -4°C or -6 or -10°C

Reason:- water is already converted into ice at 0°C, now, the decrease in temp would not affect the density bcz ice will remain ice.

•) → Water when freezes expands by 9%. from 4°C
if 100cm³ of water freezes then volume of ice will be..
$100 \times \frac{9}{100} = 9$ $100 + 9 = 109 cm^3$

$P = \frac{F}{A}$ ↑ ↓

•) Hydrogen bonding is present b/w (None)



Chloroform (polar) Acetone.

→ individually there is no H-bond bcz acc to def H must be attached directly to the F, O, N.
→ but the mixture of both will contain H-bond

Evaporation
• spontaneous escape of liquid from surface of the
• causes cooling
•) continues at all T
•) Endothermic process
•) bcz high energy molecules are present on surface.

→ **Factors**
•) E ∝ surface area
eg clothes on a string
•) E ∝ distance b/w molecules
•) $E \propto \frac{1}{IMF}$
•) $E \propto \frac{1}{\text{size of molecule}}$

V.P
Evaporation ⇌ Condensation
↳ dynamic eq
↳ taking place at equal & opposite rate)
↳ the pressure exerted by the vapours on the surface of liquid

→ **Factors** (Not affect)
• surface area (V.P = $\frac{F}{A}$)
on unit one is =

Depends
•) $V \propto \frac{1}{IMF}$ (more attraction less evaporation)
•) $V \propto \frac{1}{\text{size}}$

B.P
Temp at which vapour pressure = external pressure

Factors
•) B.P ∝ IMF
(more attraction means more force would be needed and B.P will ↑)
•) B.P ∝ external pressure
→ at diff external pressure B.P's also become diff

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measurement of vapour pressure:-

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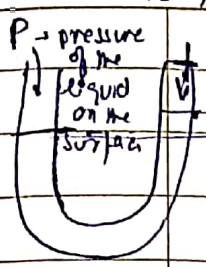
by Manometric Method → in a tube the air is trapped which is then sealed by a liquid bath,



$P = P_{atm} + \Delta H$ → is only applicable when pressure exerted by liq is greater than the atm and the change in height would be prominent

→ Boiling point

In diethyl ether V·P = 200 torr. → at 0°C

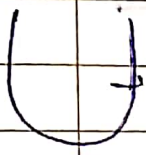
atm = 760 torr

~~200~~ V·P = atm → Boiling starts

In alcohol (at 0°C → V·P = 78·3°C) which means high B.P

In H_2O → 0°C → V·P = 4·5 → more heat provided

atm = 760 torr

→  → water boils at 100°C at 1 atm.

now water will not boil further, it will utilize the heat in evaporating its water molecules when the vessel is not covered.

↳ Molal Heat of Vaporization at 100°C.

→ steam burn at 100°C more serere than water because it also has molal heat of vaporizatio

B·P of water.	External pressure	Places
100°C	760 torr	Sea level
98°C	700 torr	Murree hills
69°C	323 torr	Mount everest
23°C	23·7 torr	Vacuum (means preamy P less than atm)
120°C ——→	1489 torr	pressure cooker

for higher T, the external pressure must be increased because at 1atm we cannot heat water above its B.P

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Vacuum Distillation

Day: Date: at n.p.s T/

Glycerine at 760 torr boils at 290°C ↗ but will also decompose

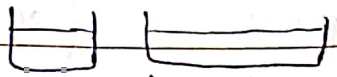
↓

So external P will be decreased: 210°C → 50 torr.
boils.

mcqs :-

→ Evaporation → endothermic → Vapour P is not affected by → amount of liquid
→ spontaneous → surface area
→ volume of container

→ Which of the following posses highest B.P



Area changed but as V.P is independent so change in V also not effects

Water → 2 H bond

✓ Ethylene Glycol → // → $CH_2-\ddot{O}H$ / $CH_2-\ddot{O}H$ → also posses London dispersion

H−Cl → P-Dipole-dipole due to E.N

CH_3CH_2OH → H. bond (1)

→ Formula of V.P through manometric method

(external pressure P exerted by the liquid)

P = Pa + ΔH if E.P > Pa

P = Pa

P = Pa − Δh E.P < Pa

↔ all are possible

→ Abundant state in univers
solids liquids gas plasma

→ most abundant in Earth crust
solids

→ least abundant on Earth
liquids

→ Highest B.P is posses by

Pentane Iso pentane

→ more L.D forces P large surface A

Neo pentane Butane

→ Highest V.P is possesed by

Butane → atomicity same

✓ Iso butane → small sized → 1/V.P

Pentane

Hexane

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Day: Date /

	Gas	Liquid	Solid
Volume	no volume bcz they adopt the V of container	✓	✓
Shape	X	X	✓ due to compact bonding
Spaces	larger spaces	comparatively small	very narrow
IMF	very low bcz molecules move randomly here & there	→ greater than gases	very strong
Motion	Trans, vib, rot K.E	Trans, vib rot	only vibration bcz molecules are very closely packed and cannot move
Density ↓ $d = \frac{m}{V\uparrow}$	very low bcz distance b/w molecules is greater	greater than gases	very high
diffusion	✓	✓ very fast	no diffusion bcz have no motion
effusion → gases releasing from a punctured pipe → perfume	✓ eg	X	X
Compression	✓	X bcz solids and liquids have fixed volume	X
expansion	✓	X	✓
Cooling	Sudden expansion Joule's Thomson's effect	evaporation	X
Pressure	Collision	W/unit area	W/A

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S, L, G

Energetics of Phase change (heat is must required)

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S —melting fusion→ L —vaporization→ G

S ←freezing— L ←condensation— G

→ S → G sublimation

G → S deposition

→ S → L ΔH_f (heat of fusion)

→ L → G ΔH_v (vaporization)

→ S → G ΔH_s sublimation

$\Delta H_S > \Delta H_V > \Delta H_f$ (least bcz S & L have no significant diff)

→ Intermolecular forces [that tend to bring two substances towards each other] → Attractive forces (A.F)

~~non-zero~~

→ Intramolecular

• force b/w atoms of the same element or diff elements to form true chemical bond

→ Ionic bond

→ covalent bond

→ Metallic bond

→ Coordinate covalent bond.

Intermolecular

→ force b/w atoms of same or diff molecules without the formation of true chemical bond

→ short ranged (weak forces).

•) London- dispersion

•) dipole dipole interaction (Keemer force)

•) Hydrogen bonding

•) Dipole (Polar) - induced non-polar dipole (Debye force)

•) Dipole - ion forces

(Vander-Waal forces)

→ B.P, M.P, viscosity, H_v, density, H_S, H_b → ∝ IMF

→ Vapour pressure ∝ 1/IMF

→ 40.7 kJ/mol → to remove IMF (Inter)

→ 920 kJ/mol → " Intra MF

} in H_2O

Intra >> Inter

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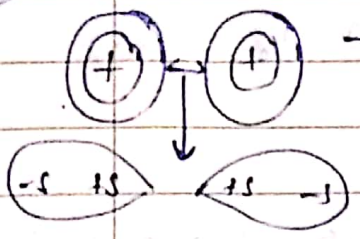
London Dispersion force

dipole +S – –S

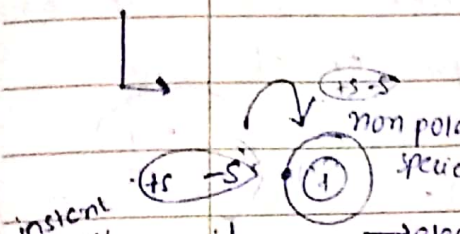
Day: Instantaneous – – – Induced
dipole. dipole

→ Fritz London (1930)

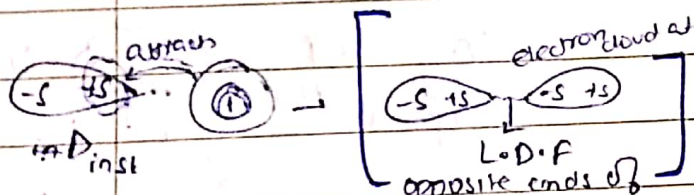
eog He



→ in normal case Electron cloud is evenly distributed but when two He atoms are repelled · electron cloud is heavier at one one & lighter at other b/w non polar species



(→ Instantaneous dipole induces polarity in a non polar specie) → (Induced dipole)



mcq:

He molecules having only non-polar force

- Ethanol H-bond
- Butanoic acid H-bond → L·D·F
- ✓ CO_2 → only L·D·F
- All of these

→ mcq

- L·D·F depends upon
- ✓ size of atom ∝ Cl, Br, I ↑ L·D·F
- ✓ Number of atom ∝ L·D·F

CH_4, CH_3CH_3, $CH_3CH_2CH_3$, $CH_3CH_2CH_2CH_3$ max L·D·F

- ✓ Shape of Molecules → straight Area ↑ → L·D·F ↑
  → branch ✗

Area of contact ↑ Pentane, isopentane, neopentane
L·D·F ↑
B·P ↑

- ✓ polarizability (measure of ease of distortion of ē cloud)

mcq

→ L·D·F is 400 times less than average covalent bond

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Dipole-Dipole Attraction: (force b/w opposite ends of two dipole)
→ exists only in polar molecules

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two ends
$H^{+\delta} - Cl^{-\delta}$ ..... $H^{+\delta} - Cl^{-\delta}$ (DDA)

→ 1% effective as covalent bond.
→ 200 times weaker than Covalent Bond (ar)
→ DDA ∝ thermodynamic parameters (m.P, B.P, ΔH_v, ΔH_s)

Factors
→ electronegativity diff
↖ [DDA ∝ $\Delta E \cdot D$] $\frac{1}{N(\Delta x)}$

↑ H-Cl H-Br H-I
→ DDA ∝ I

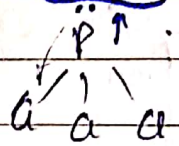
○ ○ inter molecular distance
High T, low P → DDA ↓
low T, High P → DDA ↑
○○

mcq
→ which of the following have debye forces
HCl, H_2O
✓ H_2O, Ne (P, N.P)
He, Ne
All

"force of attraction b/w polar and non-polar molecule is **Debye force**."
Or
dipole and induced dipole

mcq
↔ forces which make equilibration of He gas possible are
• Debye force • LDF
• DDA • No Equilibrium

→ Dipole-dipole (polar-polar) interaction is present in
CO_2 overall non polar | BF_3 N.P | PCl_3 | None



chloform → polar.

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